"Muscular power as a function of load in eldery women."

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Abstract

Ageing has been associated with a decrease in the ability to perform daily tasks (Reid and Fielding 2012). This decrease in functional performance is due to a lower capacity of developing muscle force and power, which results in impaired performance, particularly in activities where intense and rapid movements are essential (e.g. counter-acting a fall). It has been shown that increasing muscle power in older adults results in a functional improvement and reduces the incidence of disability (Pereira et al. 2012). To improve muscular power, trainings that maximise power output are indicated (Kawamori and Haff 2004). Muscular power can be assessed using iso-kinetic or iso-inertial dynamometry. Even if iso-kinetic testing remains one of the more popular methods for power assessment, it may not be appropriate to assess the ability to perform daily tasks (Jane 1995). Indeed, the fixed velocity of movement utilised during iso-kinetic testing is not characteristic of most daily activities. I...

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Muscular power as a function of load in elderly women

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Keywords: muscular power; muscular strength; strength and power training; older women; geriatrics

1. Introduction

Ageing has been associated with a decrease in the ability to perform daily tasks (Reid and Fielding 2012). This decrease in functional performance is due to a lower capacity of developing muscle force and power, which results in impaired performance, particularly in activities where intense and rapid movements are essential (e.g. counter-acting a fall).

It has been shown that increasing muscle power in older adults results in a functional improvement and reduces the incidence of disability (Pereira et al. 2012). To improve muscular power, trainings that maximise power output are indicated (Kawamori and Haff 2004).

Muscular power can be assessed using iso-kinetic or iso-inertial dynamometry. Even if iso-kinetic testing remains one of the more popular methods for power assessment, it may not be appropriate to assess the ability to perform daily tasks (Jane 1995). Indeed, the fixed velocity of movement utilised during iso-kinetic testing is not characteristic of most daily activities. Instead, iso-inertial testing approximates more closely functional movements, which are characterised by accelerations of a constant mass.

In this study, we have measured the average power during upper and lower body exercises using an iso-inertial method in older women. The aim was (1) to evaluate the strength and power in ageing women and (2) to determine the load (or range of loads) that maximises the mechanical power output.

2. Methods

Thirty-four older women, 60–81 years of age (age: 65.7 ± 4.8 years; height: 1.47 ± 0.04 m; body mass: 68.2 ± 12.4 kg; mean ± SD) participated in this study. Informed consent was obtained. Subjects were not suffering from any pathology that could severely disrupt the full range of movement. Project was approved by the local ethics committee.

Subjects were first familiarised with the equipment. During a second session, the maximal load lifted and the power necessary to lift this load were assessed: first the bench press test (BP) and then the leg press test (LP), with 1-hour rest between tests. BP exercises were performed on a Smith Machine S3-020 and LP exercises on a Leg Press S3-022 (R2sport, Forest Park, Illinois, USA).

An optical rotary encoder (Globus Real Power, Codogne, Italy) measured the position of the bar supporting the weights every 1 ms (precision: 1 mm). The average power spent during the concentric phase was then computed as the product of the average velocity times the mean force (Real Power Software 20.40).

Subjects started from a fully extended elbow/knee position, and then they were lowering the bar, until the elbow/knee reached an angle of 90°. Then, subjects performed a concentric contraction of the extensor muscles as fast as possible until full elbow/knee extension. All subjects started with an empty bar (mass: 11 kg for BP and 40 kg for LP), thereafter the load was progressively increased by adding masses (2.5–5 kg for BP and 10–25 kg for LP). The load increments were performed until the subject was unable to reach the full extension. A 2-minute rest was given between each trial. The full extension with the highest load was determined as 1 repetition maximum (1RM)-BP/LP.

Results were grouped in classes of 10% of 1RM. The data were compared using one-way analysis of variance and Bonferoni *post hoc* comparisons.

3. Results

The weight-specific 1RM-BP is 0.41 ± 0.11 body weight (BW; mean ± SD) and the 1RM-LP is 2.15 ± 0.54 BW. We did not find a significant correlation between age and 1RM-BP ($r = -0.23$, $P > 0.08$), whereas 1RM-LP decreased significantly with age ($r = -0.59$, $P < 0.001$).

Both in BP and LP the average speed of movement decreases linearly when the load increases (Figure 1), from $0.6\,\mathrm{ms}^{-1}$ at 20% of 1RM to $0.2\,\mathrm{ms}^{-1}$ at 1RM.

The power developed during the extension of the upper and the lower limbs presents an inverted U-shaped curve (Figure 1) with a maximal power output for a load of ~60% of 1RM. In BP (upper panel), the average power output was

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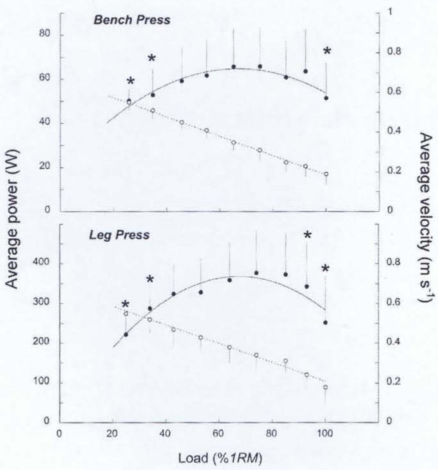

Figure 1. Average power (filled circles) and velocity (open circles) as a function of the load (expressed as a percentage of the 1 repetition maximum, 1RM) during an extension movement of the upper limbs (upper panel) and of the lower limb (lower panel). Each point is the average of all the data obtained within a 10% load class. Bars represent ±1SD. Linear (interrupted line) and polynomial (continuous line) curve fit are computed through all the data (KGraph 4.5). *The classes where the power is significantly lower than the maximal power.

not significantly different across the load range of 40–90% of 1RM, whereas it was significantly lower ($P < 0.001$) for loads of 20%, 30% and 100% of 1RM.

In LP, the average power output was not significantly different across the load range of 40–80% of 1RM. For load <40% and >80% of 1RM, the power was significantly lower ($P < 0.001$).

4. Discussion and conclusions

For BP, the weight-specific average 1RM measured on elderly Chilean women (0.41 ± 0.11 BW) is in agreement with the norms of the American College of Sports Medicine (0.45 ± 0.28 BW), but are higher than the values of the Women's Exercise Research Center (0.30 ± 0.12 BW) (Brown and Miller 1998). For LP, our subjects were lifting a weight put on a rail inclined at 45°, whereas in the two other studies, the subjects were using a sitting leg press and lift the weight vertically. For comparison, our values should be multiplied by sin45°. In this case, Chilean women: 1.52 ± 0.39 BW – American College of Sports Medicine: 1.03 ± 0.37 BW – Women's Exercise Research Center: 1.16 ±·0.37 BW. Note that both in BP and LP, the standard deviations are rather important, showing the great dispersion of the muscular force observed in elderly women. In our study, the mean power was maximised for a load of 60–65% 1RM during BP and LP exercises, although mean power output was not significantly different across the load ranges of 40–90% 1RM for BP and 40–80% 1RM for LP. These results are in concordance with the study of de Vos et al. (2005). Our results suggest that there is no optimal load to develop muscle power in older women, but rather a range of loads that can be used to optimise the development of muscle power. Several studies have analysed the influence of the velocity component of muscle power on functional performance and have demonstrated that high velocity maximal power training are the most efficient to improve muscle maximal power in older adults (Henwood et al. 2008). The findings described here suggest that even if power output is similar at certain points along the power curve, the different velocities at which power is obtained could be a key factor in functional responses. Therefore, we recommend peak muscle power training with loads of 40–50% 1RM, rather than 70–80% 1RM. Furthermore, higher leg press velocity is associated with better performance in maintaining balance (Marsh et al. 2009), better mobility and better walking performance in the elderly population (Sayers et al. 2005). Note that certain tasks may require power with a great force rather than power with a great velocity. Enhancing muscle strength remains thus an important component of functional training programs, especially in the long-term development of maximal muscular power (Zamparo et al. 2002).

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